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(54) **Modular sensing system for a digital radiation imaging apparatus and method of constructing the sensor system**

Modulares Sensorsystem für eine digitale Strahlungsbildaufnahmevorrichtung und Methode zur Konstruktion des Sensorsystems

Système modulaire de détection pour un appareil d'imagerie numérique de radiation et méthode pour la construction du système de détection

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EP 0 776 126 B1

Description

[0001] The present invention relates to a method of constructing a sensor system which is sensitive to electromagnetic radiation and is suitable for use in a digital imaging camera head, said sensor system delivering an electrical signal containing the image information formed by electromagnetic radiation incident on the sensor system.

[0002] The invention also concerns a solid-state sensor system of a CCD camera head intended for digital imaging, said sensor system comprising a radiation-responsive detector element array with control electronics connected thereto and an interface unit by which the sensor system is connected to an image recording apparatus, and said sensor system further comprising a frame unit, on which the sensor system is adapted.

[0003] The present invention relates broadly to object imaging by means of electromagnetic radiation. In particular, the invention is related to digital imaging utilizing CCD sensor systems.

[0004] The method and apparatus according to the invention are intended broadly for digital imaging and particularly for medical x-ray imaging such as panoramic dental radiography and mammography.

[0005] Conventionally, digital imaging is also used in medical x-ray technology, wherein it has certain indisputable benefits over the use of radiation-sensitive film requiring a development process. Such benefits are those related to viewing, handling, storage and remote transfer of digitally imaged and stored picture information which in the future will be further accentuated when the medical services and hospital systems will increasingly move into digital techniques in general and particularly in the processing of x-ray images and similar information. Hence, it is one of the principal objects of the present invention to bring an essential advancement to this on-going trend.

[0006] As to their basic structure, solid-state sensors intended for digital imaging comprise small radiation-sensitive detector elements called pixels arranged into larger planar arrays, or in a simplified form, into a single-row line sensor. Electromagnetic radiation such as light, infra-red radiation or x-rays absorbed at the area of the detector elements generates an electrical charge in the elements with a magnitude dependent on the intensity of absorbed radiation (that is, flux density and energy of absorbed quanta) of impinging radiation. Here, the magnitude of the electrical charges grows as a function of time, which means that during the exposure time, the detector element integrates the charge generated by the radiation impinging over the sensor area, thus in principle giving a possibility of controlling the magnitude of the detector element output signal through varying the integration time.

[0007] In the prior art, CCD (Charge-Coupled Device) image sensors and their control electronics were designed and optimized always separately for a certain application and specific use, whereby such conventional image sensor systems are ill fit for other applications no matter how similar. The development of new types of CCD sensors is extremely expensive and time-consuming. Typically, a new type of CCD sensor takes at least a year or more involving an R&D budget of at least USD 1 million. Correspondingly, the development of control electronics for such a new CCD sensor takes about the same time, raising the system R&D costs by at least about USD 250,000. Given these facts, it is obvious that since the development of a new CCD sensor type presumes a practical application with a commercial potential of development cost payback in a reasonable time, applications using small quantities of CCD sensors cannot be implemented in practice within the constraints of a reasonable cost budget. On the other hand, while new CCD sensors are continually developed for applications of reasonably high volume, even in such projects the proportion of costs attributed to the CCD sensors rises relatively high when conventional techniques are used.

[0008] A single solid-state sensor chip, particularly a CCD sensor, made by concurrent technology has such a small active area that any larger image area cannot be recorded by means of a single sensor, particularly when reasonably or extremely high requirements are set for the sensor sensitivity as is the case in x-ray imaging. Resultingly, a number of CCD sensor chips with control circuit blocks are necessary in the construction of a complete digital camera head.

[0009] As known in the art, digital camera heads with their image sensors and control circuitry are generally designed for a certain application, which makes them unsuitable for modification or adaptation to any other application whether similar or not. For example, with the help of time-delayed integration (TDI) technique, applications can be found in, e.g., mammography or panoramic x-ray imaging of dental or skull areas in which a single basic construction of the imaging apparatus is produced in modified versions for these applications that differ from each other chiefly by the active area of the imaging sensor only. In mammography equipment, the length of the scanning CCD line sensor typically is either 18 cm or 24 cm, depending on whether image areas of 18 x 24 cm or 24 x 30 cm are being recorded. In panoramic imaging equipment, the length of the scanning CCD line sensor typically is approx 14 cm for panoramic imaging alone and 18 cm or 24 cm for different modes of skull imaging.

[0010] DE-A-3932845 discloses a dental video camera system for inner mouth X-ray image reproduction. The system comprises a video camera having an electronic image taking part and a screen for an X-ray image reproduction, between which and the image taking part is an optical system for a reduced size image. In the system several optical elements and electronic image taking parts are provided for each screen.

[0011] Today, the purchase decision of a digital CCD camera head must be based on knowledge covering all

possible future applications, thus assuring the suitability of the purchased equipment version for all of them, because retrofitting of a camera head implemented by means of conventional technology is not either possible, or if possible, requires a complete replacement of the CCD camera head with another type, which obviously is an uneconomical operation. On the other hand, the purchase of a CCD camera head with an imaging area covering the maximum size required by any conceivable application is impractical, because the price of this type of imaging system is chiefly determined by the CCD sensor assembly itself and its control electronics, whereby the equipment price can easily double from the inclusion of a provision covering all possible future imaging needs that may well remain unrealized.

[0012] Another problem related to conventional digital CCD camera head systems is servicing of the equipment. When even a slight malfunction occurs the CCD sensor of the equipment or its control electronics, the sensor must be replaced as a whole unit, which by its servicing cost rises close to the purchase price of new camera head. If fabricated by conventional techniques, an integrally bonded CCD sensor package must always be replaced as a whole unit even if only a small component actually fails therein. Similarly, the control electronics of the imaging system have conventionally been designed and traditionally built for the entire sensor package, whereby its malfunction has also required the replacement of the entire electronics package.

[0013] It is a broad object of the present invention to further develop the sensor systems of digital camera heads, particularly those based on CCD sensors, so that the above-discussed problems are extensively solved and the drawbacks eliminated.

[0014] It is a particular object of the present invention to achieve such a sensor system suited for medical x-ray imaging, particularly mammography and panoramic dental or skull radiography, that offers improved flexibility in its realization and higher cost-efficiency so that different imaging modes and later needs for wider imaging areas can be implemented with a higher economy and lower investment costs over those possible through conventional techniques.

[0015] It is a further particular object of the present invention to achieve such a CCD sensor system, particularly suited for medical x-ray technology, that offers simplified and more economical servicing combined with a significantly reduced number of spare parts and costs over the prior art.

[0016] To achieve the above-stated goals of the invention and others to be explained later, the method according to the invention is principally characterized by the features of the characterizing part of claim 1. Furthermore, the apparatus according to the invention is prin-cipally characterized by the features of the characterizing part of claim 6.

[0017] The sensor system according to the invention has a modular construction that can be expanded or reduced as required by imaging needs in an economically advantageous manner through simple and rapid operations. Additionally, the invention offers benefits related to servicing of the sensor system, since the modular structure of the sensor units permits replacement of a malfunctioning modular unit alone, that is, a modular sensor unit and/or its control electronics unit can be changed without the need for replacing the entire CCD sensor system with its dedicated control electronics. Other effects and advantages of the invention will become evident from the description below.

[0018] In the following the invention will be examined in greater detail by making reference to the diagrams of appended drawings illustrating diagrammatically a few exemplifying embodiments of the invention, whereby the details of the diagrams must not be understood as limiting the scope of the invention, in which drawings

Figure 1 is a schematic block diagram of a sensor system according to the invention;

Figure 2 is a more detailed block diagram of a modular control electronics unit for one modular sensor unit;

Figure 3 is a block diagram of a base unit common to all modular units of a sensor system;

Figure 4 is a sectional side view of an embodiment of a sensor system according to the invention taken along the longitudinal axis of the sensor assembly;

Figure 5 shows a cross-sectional view of the assembly of Fig. 4, now taken along a plane perpendicular to the plane of the longitudinal section;

Figure 6 is a perspective view of a mammography unit suitable for acting as an application platform for an embodiment of the invention; and

Figure 7 is a perspective view of a panoramic dental x-ray apparatus suitable for acting as an application platform for an embodiment of the invention.

[0019] Referring to Fig. 1, a sensor system 100 according to the invention may have, e.g., such a structure as is diagrammatically shown therein. Here, the sensor system 100 is assembled from a required number of modular solid-state sensor units $10_1 ... 10_N$, each of which is connected to its dedicated modular control electronics unit $20_1 ... 20_N$, whose number N thus is equal to that of the sensor units 10. The control electronics units are in turn attached to a common base unit 80 having an uncomplicated construction serving to interface the sensor system 100 to an imaging system 90 proper. With varying sizes of the sensor system, the imaging system 90 with the common base unit 80 remain unchanged and the dimensions of the imaging area re-

quired in each application can be set by selecting a proper number N of the modular sensor units 10 and their respective modular control electronics units 20. The base unit 80 is already initially made so wide that it as such permits maximal expansion of the sensor system 100. Alternatively, retrofit expansion of the sensor system can be made by attaching a second base unit 80 adjacent to the first one.

[0020] Referring to Fig. 2, the modular control electronics unit 20 for one modular sensor unit 10 is shown in a detailed block diagram. The control electronics unit 20 is connected by the upper signal lines 20b to the sensor unit 10 and by the lower signal lines 20a to the base unit 80 (shown in Figs. 1 and 3). The control electronics unit 20 contains all elements necessary for controlling one sensor unit 10 such as control signal buffer stages 21, voltage regulator 25 of the supply voltages required by the sensor unit, sensor unit output voltage amplifier 22, a CDS circuit 23 required for interfacing CCD sensors and an analog/digital converter 24 for the output signals.

[0021] Referring to Fig. 3, therein is shown the configuration of a base unit 80 common to the modular sensor and control electronics units $10_1...10_N$, $20_1...20_N$. The base unit 80 is connected by its right side signal lines 80a to an imaging apparatus 90, wherefrom the base unit 80 receives its supply voltages and synchronizing signals and whereto it delivers the image information retrieved from the modular sensor units $10_1...10_N$. In Fig. 3, interfacing to the sensor system 100 is shown implemented so that a power supply 83 delivers the supply voltages to each sensor/control electronics unit pair 10,20, while a synchronizing pulse generator 82 provides the timing signals required for controlling said units. A data collection unit 81 receives the image information delivered by each sensor/control electronics unit pair 10,20 and forwards the information in processed form to the imaging apparatus 90.

[0022] Referring to Figs. 4 and 5, an assembled sensor system is comprised of modular CCD sensor units $10_1...10_3$ with optical fibers $60_1...60_3$ bonded at their lower ends with an adhesive to the detector element and having a scintillation material layer $61_1...61_3$ at their upper ends. Each sensor unit $10_1...10_3$ connected to its dedicated control electronics unit $20_1....20_3$ via a connector $64_1...64_3$ located in a hole $63_1...63_3$ made to the frame 62, whereby the contact pins of the sensor unit $10_1...10_3$ are aligned for insertion into the connectors. Correspondingly, the modular control electronics units $20_1...20_3$ attached via connectors $65_1...65_3$ to the common base unit 80 of the CCD camera head that further has a connector 66 for interfacing to an imaging apparatus 90. The sensor units 10 are mounted in place longitudinally end-to-end between clamp pieces 70 under a suitable compression imparted by a screw 71 and a spring 72. In the lateral direction, each sensor unit 10 is fixed between its own clamp pieces 73, tightened in place by means of screws 74 and a spring 75. By providing clamp pieces 73 on both sides of the set of modular sensor units 10 with an adjustment screw set or similar arrangement, the sensor unit set may be accurately aligned on a single line as required with the help of the clamping arrangement of the sensor units 10 shown in Figs. 4 and 5. As the detector elements of the sensor units 10 are also responsive to visible light, they are enclosed in a dark space sealed with a protective cover 67 transparent to x-rays. The base unit 80 is attached to the frame 62 by means of standoffs 68.

[0023] In Fig. 4 is shown such an embodiment of the invention having the camera head provided with a facility for retrofit installation of a fourth sensor unit 10_4. For this purpose, the support frame 62 is provided with an opening 63_4 and a connector 64_4 in the base unit 80. Initially, the extra sensor unit 10_4 is replaced by a filler piece 69 having a thermal expansion coefficient essentially equal to that of the sensor units $10_1...10_3$.

[0024] Thus, any of the sensor units $10_1...10_3$ can be replaced simply by untightening the fixing screws 71 and 74 and removing the cover 67. Thence, the filler piece 69 may be replaced by an extra sensor unit 10_4,20_4, or alternatively, any redundant sensor unit 10 may be replaced by a second filler piece 69. Similarly, any of the sensor-unit-specific control electronics units 20 may be replaced, added or removed through simply detaching the base unit 80.

[0025] The fibers of the optical fiber system 60 are tapered toward the detector elements, whereby a contiguous imaging area free from inter-unit borders can be achieved even in structures not having the active imaging area of the sensor units 10 extending up to the edges of the sensor units. In Figs. 4 and 5, reference letter a denotes the taper angle of the optical fibers 10.

[0026] The above-described advantageous embodiment of a sensor system assembled using the method according to the invention is such that has a scanning sensor with a length corresponding to the active imaging area width scanned by the sensor head, whereby the width of the imaging area is set by the length of the scanning motion of the sensor head. When adapting the invention to such scanning sensor heads, concurrently also the TDI (Time Delayed Integration) imaging principle is used that is known in the art and is explained in more detail in FI Patent No. 97665.

[0027] Referring to Fig. 6, a mammography apparatus suited for use as an application platform for the present invention is shown therein standing on a base 30. To the base 30 is attached a fixed vertical column section 32 with a motor 31 inside the fixed section actuating a telescopically movable vertical column section 38. The vertical column houses a motor 33 for rotating a C-arm 44 about a horizontal axis H-H. One end of the C-arm supports an x-ray generator 42, while the other end of the arm carries a lower compression paddle 36 against which a breast M to be radiographed is compressed with the help of an upper compression paddle 43 actuated by a motor 34. During the exposure of the breast M, a

narrow x-ray beam 41 emitted by an x-ray tube 39 passes through a primary blind 47, which is adapted laterally movable by means of a motor 40, then passes through the breast M being radiographed and finally is incident on a sensor head 45, which is adapted simultaneously movable with the primary blind by means of a motor 35 and comprises a CCD sensor system 100 having a modular construction of the above-described type according to the invention.

[0028] In Fig. 7 is shown a panoramic x-ray apparatus principally intended for dental radiography, comprised of a vertical column 50 carrying a horizontal support arm 51, adapted vertically movable by means of a motor 55 and rotatable by means of a motor 54, said horizontal support arm carrying at its one end an x-ray generator 52, whereby a narrow x-ray beam 56 emitted by the generator passes through the tissues of a patient P from one side and is on the other side incident on a sensor head 53 comprising a CCD sensor system 100 having a modular construction of the above-described type according to the invention.

[0029] In mammography, the invention can be utilized by first purchasing a CCD sensor system 100 equipped for imaging 18 by 24 cm areas only, and later, if so required, the sensor system 100 can be retrofitted for a larger imaging area of 24 by 30 cm. Similarly, in panoramic dental radiography a CCD sensor system 100 initially equipped for panoramic dental exposures only can be retrofitted for skull imaging in one or even several steps, e.g., first for the 18 cm image format and later for the 24 cm image format.

[0030] With regard to a detailed description of the modular sensor units 10 and the sensor system 100, reference is made to FI Patent No. 97665.

Claims

1. A method of constructing a sensor system (100) which is sensitive to electromagnetic radiation and is suitable for use in a digital imaging camera head, said sensor system (100) delivering an electrical signal containing the image information formed by electromagnetic radiation incident on the sensor system (100) and said sensor system (100) comprising of a number (N pcs.) of mutually essentially identical modular sensor units ($10_1 ... 10_N$) and of an equal number (N pcs.) of mutually essentially identical modular control electronics units ($20_1 ... 20_N$) suited for the control and signal processing of said sensor units ($10_1 ... 10_N$), **characterized** in that the method comprises the steps of adapting and arranging the modularity of the sensor system (100) so that the dimensions of the imaging area covered by the sensor system (100) can be expanded or reduced as required for the needs of an imaging application by adding or reducing, respectively, the number of the modular sensor units (10,20), and making each individual modular sensor unit (10) and/or control electronics unit (20) separately removable for servicing.

2. A method as defined in claim 1, **characterized** in that in the method the sensor system (100) is formed by mounting modular sensor units (10) end-to-end and/or adjacently in parallel.

3. A method as defined in claim 1 or 2, **characterized** in that the method uses N = 3-10 pcs. mutually identical modular sensor units (10) and the same number (N pcs.) of mutually identical modular control electronics units (20).

4. A method as defined in any of claims 1 - 3 adapted to x-ray mammography, **characterized** in that the sensor head of the mammography apparatus is formed by arranging 6-8 pcs., advantageously 6 pcs. mutually identical modular CCD sensor units (10) and the same number of mutually identical modular control electronics units (20) connected thereto.

5. A method as defined in any of claims 1 - 3 adapted to a combined panoramic dental/skull radiographic apparatus, **characterized** in that in the panoramic dental radiography setup the sensor head is formed by arranging 4-6 pcs., advantageously 4 pcs. mutually identical modular sensor units (10,20) and that in the skull imaging setup the same sensor system (100) is used as in the panoramic dental radiography setup through retrofitting the system with 1-4 pcs. of modular sensor units (10, 20).

6. A solid-state sensor system suitable for use in a CCD digital imaging camera head, said sensor system (100) comprising a detector element array sensitive to radiation and a control electronics block connected thereto and an interface unit (65,66,80) by which the sensor system (100) is connected to an image recording apparatus (90), and said sensor system (100) further comprising a frame unit (62,67,68,70,71,72) on which the sensor system (100) is adapted and said solid-state sensor system (100) being designed into a modular system comprised of a number (N pcs.) of mutually essentially identical modular CCD sensor units ($10_1 ... 10_N$) and of an equal number (N pcs.) of mutually essentially identical modular control electronics units ($20_1 ... 20_N$), each of which being connected to its respective modular sensor unit (10_1), **characterized** in that said sensor system (100) further incorporates a base unit (80) for the assembly of said modular sensor unit (10,20), whereby said modular sensor units (10,20) can be added, removed and replaced as necessary for expanding or reducing of the imaging area of said sensor system (100) and servic-

ing the system.

7. A sensor system as defined in claim 6, **characterized** in that the sensor system (100) comprises a set of modular CCD sensor units (10) with an optical fiber system (60) connected thereto and that the outer surface of the optical fibers (60) are covered by a layer of scintillation material (61) capable of converting the image information conveyed by x-rays incident thereon into light in the visible range.

8. A sensor system as defined in claim 7, **characterized** in that the fibers of the optical fiber system (60) are tapered with a small tapering angle (a) toward the detector elements, whereby a contiguous imaging area free from inter-unit borders can be achieved even in structures not having the active imaging area of the sensor units (10) extending up to the edges of the sensor units (10).

9. A sensor system as defined in any of claims 6-8, **characterized** in that the sensor system (100) comprises a frame unit with a base unit (80) for mechanical and electrical connections permitting the connection of said modular control electronics units (20) via a first set of connectors (65) to said base unit (80) and via second set of connectors (64) to their respective modular sensor units (10).

10. A sensor system as defined in any of claims 6-9, **characterized** in that said sensor system (100) comprises a frame unit (62,68) incorporating an x-ray transmissive nontransparent protective cover (67) with said modular sensor units (10) placed end-to-end thereunder, whereby that side of said frame unit (62,68) which is opposite to said protective cover (67) is provided with openings (63) via which said modular sensor units (10) are connected by means of said connectors (64) to their respective modular control electronics units (20).

11. A sensor system as defined in any of claims 6-10, **characterized** in that said modular sensor units (10) are support both longitudinally and laterally in place by means of support elements (70,73), of which support elements at least ones bracing the opposed sides of the adjacently mounted set of modular sensor units (10) are provided with clamping members, most advantageously with spring and screw elements (71,72,74,75) suited for fixing said sets of modular sensor units (10) to said frame unit (62) and aligning said sensor unit sets as required.

Patentansprüche

1. Verfahren zum Aufbau eines Sensorsystems (100), das auf elektromagnetische Strahlung anspricht und zur Verwendung in einem digitalen Abbildungskamerakopf geeignet ist, wobei das Sensorsystem (100) ein elektrisches Signal liefert, das die Bildinformationen enthält, die durch auf das Sensorsystem (100) fallende elektromagnetische Strahlung gebildet werden, und wobei das Sensorsystem (100) eine Anzahl (N Stück) von gegenseitig im wesentlichen identischen modularen Sensoreinheiten (10_1 ... 10_N) und die gleiche Anzahl (N Stück) von gegenseitig im wesentlichen identischen modularen Steuerelektronikeinheiten (20_1 ... 20_N) aufweist, die zur Steuer- und Signalverarbeitung der Sensoreinheiten (10_1 ... 10_N) geeignet sind, **dadurch gekennzeichnet, dass** das Verfahren die Schritte der Anpassung und Anordnung der Modularität des Sensorsystems (100) derart umfasst, dass die Dimensionen der durch das Sensorsystem (100) abgedeckten Abbildungsfläche je nach Bedarf einer Abbildungsanwendung vergrößert oder verkleinert werden kann, indem die Anzahl der modularen Sensoreinheiten (10, 20) jeweils vergrößert oder verkleinert wird, und indem jede einzelne modulare Sensoreinheit (10) und/oder Steuerelektronikeinheit (20) separat zur Wartung entfernbar ausgebildet wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** bei dem Verfahren das Sensorsystem (100) durch Befestigen modularer Sensoreinheiten (10) endweise und/oder angrenzend parallel ausgebildet wird.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Verfahren N = 3 - 10 Stück gegenseitig identische modulare Sensoreinheiten (10) und die gleiche Anzahl (N Stück) gegenseitig identischer modularer Steuerelektronikeinheiten (20) verwendet.

4. Verfahren nach einem der Ansprüche 1 bis 3, das für eine Röntgenmammografie angepasst ist, **dadurch gekennzeichnet, dass** der Sensorkopf des Mammografiegeräts durch die Anordnung von 6 bis 8 Stück, vorteilhafter Weise 6 Stück, gegenseitig identischer modularer CCD-Sensoreinheiten (10) und der gleichen Anzahl daran angeschlossener gegenseitig identischer modularer Steuerelektronikeinheiten (20) ausgebildet wird.

5. Verfahren nach einem der Ansprüche 1 bis 3, das an ein kombiniertes Panorama-Zahn/Schädel-Röntgengerät angepasst ist, **dadurch gekennzeichnet, dass** bei der Panorama-Zahnröntgeneinstellung der Sensorkopf durch die Anordnung von 4 bis 6 Stück, vorteilhafter Weise 4 Stück, gegenseitig identischer modularer Sensoreinheiten (10, 20) gebildet wird, und dass bei der Schädelabbildungseinstellung das gleiche Sensorsystem (100)

wie bei der Panorama-Zahnröntgeneinstellung verwendet wird, indem das System mit 1 bis 4 Stück modularer Sensoreinheiten (10, 20) nachgerüstet wird.

6. Festkörpersensorsystem zur Verwendung in einem CCD-Digitalabbildungskamerakopf, wobei das Sensorsystem (100) ein auf Strahlung ansprechendes Erfassungselementarray und einen mit diesem verbundenen Steuerelektronikblock und eine Schnittstelleneinheit (65, 66, 80) aufweist, durch das das Sensorsystem (100) mit einem Bildaufzeichnungsgerät (90) verbunden ist, und das Sensorsystem (100) ferner eine Rahmeneinheit (62, 67, 68, 70, 71, 72) aufweist, auf dem das Sensorsystem (100) angepasst wird, und das Festkörpersensorsystem (100) als Modularsystem entworfen ist, das eine Anzahl (N Stück) von gegenseitig im wesentlichen identischen modularen CCD-Sensoreinheiten (10_1 ... 10_N) und die gleiche Anzahl (N Stück) von gegenseitig im wesentlichen identischen modularen Steuerelektronikeinheiten (20_1 ... 20_N) aufweist, die jeweils mit ihrer entsprechenden modularen Sensoreinheit (10_i) verbunden sind, **dadurch gekennzeichnet, dass** das Sensorsystem (100) ferner eine Basiseinheit (80) für die Zusammensetzung der modularen Sensoreinheit (10, 20) enthält, wodurch die modularen Sensoreinheiten (10, 20) hinzugefügt, entfernt und ersetzt werden können, wie es zur Vergrößerung oder Verkleinerung der Abbildungsfläche des Sensorsystems (100) und Wartung des Systems erforderlich ist.

7. Sensorsystem nach Anspruch 6, **dadurch gekennzeichnet, dass** das Sensorsystem (100) einen Satz modularer CCD-Sensoreinheiten (10) mit einem daran angeschlossenen Glasfasersystem (60) umfasst, und dass die äußere Oberfläche der Glasfasern (60) durch eine Schicht aus Scintillationsmaterial (61) bedeckt ist, das die Bildinformationen, die durch die darauf fallenden Röntgenstrahlen geführt werden, in sichtbares Licht umwandeln kann.

8. Sensorsystem nach Anspruch 7, **dadurch gekennzeichnet, dass** sich die Fasern des Glasfasersystems (60) mit einem kleinen Kegelwinkel (a) in Richtung der Erfassungselemente verjüngen, wodurch eine benachbarte Abbildungsfläche frei von Begrenzungen zwischen Einheiten selbst bei Strukturen erreicht werden kann, bei denen sich die aktive Abbildungsfläche der Sensoreinheiten (10) nicht bis zu den Kanten der Sensoreinheiten (10) erstreckt.

9. Sensorsystem nach einem der Ansprüche 6 bis 8, **dadurch gekennzeichnet, dass** das Sensorsystem (100) eine Rahmeneinheit mit einer Basiseinheit (80) für mechanische und elektrische Verbindungen umfasst, die die Verbindung der modularen Steuerelektronikeinheiten (20) über einen ersten Satz von Verbindungen (65) mit der Basiseinheit (80) und über einen zweiten Satz von Verbindungen (64) mit ihren jeweiligen modularen Sensoreinheiten (10) erlauben.

10. Sensorsystem nach einem der Ansprüche 6 bis 9, **dadurch gekennzeichnet, dass** das Sensorsystem (100) eine Rahmeneinheit (62, 68) umfasst, die eine nichtdurchlässige Schutzabdeckung (67) bezüglich einer Röntgentransmission enthält, wobei die modularen Sensoreinheiten (10) endweise darunter platziert sind, wobei die der Schutzabdekkung (67) gegenüberliegende Seite der Rahmeneinheit (62, 68) mit Öffnungen (63) versehen ist, über die die modularen Sensoreinheiten (10) mittels der Verbindungen (64) mit ihren jeweiligen modularen Steuerelektronikeinheiten (20) verbunden sind.

11. Sensorsystem nach einem der Ansprüche 6 bis 10, **dadurch gekennzeichnet, dass** die modularen Sensoreinheiten (10) sowohl longitudinal als auch lateral mittels Trägerelementen (70, 73) am Platz gehalten werden, wobei zumindest die Trägerelemente, die die gegenüberliegenden Seiten des angrenzend befestigten Satzes modularer Sensoreinheiten (10) umklammern, mit Klemmelementen versehen sind, am besten mit Feder- und Schraubenelementen (71, 72, 74, 75), die zum Fixieren der Sätze modularer Sensoreinheiten (10) an der Rahmeneinheit (62) und Ausrichten der Sensoreinheitsätze nach Bedarf geeignet sind.

Revendications

1. Procédé de construction d'un système (100) de capteurs, qui est sensible à un rayonnement électromagnétique et convient pour être utilisé dans une tête de caméra d'imagerie numérique, ledit système (100) de capteurs délivrant un signal électrique contenant l'information d'image formée par le rayonnement électromagnétique rencontrant le système (100) de capteurs, celui-ci comprenant un nombre (N unités) d'unités modulaires formant capteurs (10_1 ... 10_N) essentiellement identiques et un nombre identique (N unités) d'unités électroniques modulaires de commande (20_1 ... 20_N) essentiellement identiques convenant pour la commande et le traitement des signaux desdites unités formant capteurs (10_1 ... 10_N), caractérisé en ce qu'il consiste à adapter et à agencer la modularité du système (100) de capteurs de manière que les dimensions de la zone de formation d'image couverte par lui peuvent être étendues ou réduites comme requis pour les besoins d'une application d'imagerie par

addition ou réduction respectivement du nombre des unités modulaires formant capteurs (10, 20) et agencement de chaque unité modulaire individuelle formant capteur (10) et/ou de chaque unité électronique de commande modulaire individuelle (20) de manière qu'elles soient amovibles séparément pour leur maintenance.

2. Procédé selon la revendication 1, caractérisé en ce que le système (100) de capteurs est formé par montage d'une unité modulaire formant capteurs (10) bout-à-bout et/ou parallèles dans des positions adjacentes.

3. Procédé selon la revendication 1 ou 2, caractérisé par l'utilisation de N = 3 à 10 unités modulaires formant capteurs (10) identiques et du même nombre (N unités) d'unités électroniques modulaires de commande identiques (20).

4. Procédé selon l'une quelconque des revendications 1 à 3, adapté à la mammographie aux rayons X, caractérisé en ce que la tête à capteurs du dispositif de mammographie est formée par l'utilisation de 6 à 8 unités, avantageusement 6 unités modulaires formant capteurs CCD identiques (10) et du même nombre d'unités électroniques modulaires identiques de commande (20) qui sont connectées aux autres unités.

5. Procédé selon l'une quelconque des revendications 1 à 3, adapté à un dispositif combiné de radiographique panoramique des dents ou du crâne, caractérisé en ce que dans le montage de radiographie panoramique des dents, la tête à capteurs est formée par mise en place de 4 à 6 unités, avantageusement 4 unités modulaires identiques formant capteurs (18, 20) et que dans le montage d'imagerie du crâne, on utilise le même système (100) de capteurs que dans le montage de radiographie panoramique dentaire en complétant le système avec 1 à 4 unités modulaires formant capteurs (10, 20).

6. Système de capteurs à l'état solide destiné à être utilisé dans une tête de caméra d'imagerie numérique CCD, ledit système (100) de capteurs comprenant un réseau d'éléments détecteurs sensible au rayonnement et un bloc électronique de commande connecté à ce réseau, et une unité d'interface (65, 66, 80) au moyen de laquelle le système (100) de capteurs est connecté à un dispositif d'enregistrement d'images (90), et ledit système (100) de capteurs comprend en outre une unité formant cadre (62, 67, 68, 69, 70, 71, 72) sur laquelle le système (100) de capteurs est adapté, et ledit système de capteurs à l'état solide (100) étant agencé sous la forme d'un système modulaire représenté par un nombre (N unités) d'unités modulaires formant capteurs CCD sensiblement identiques (10_1 ... 10_N) et d'un nombre égal (N unités) d'unités d'électronique modulaires de commande sensiblement identiques (20_1 ... 20_N) chacune de ces unités étant connectée à son unité modulaire respective capteur (10_i), caractérisé en ce que ledit système (100) de capteurs comprend en outre une unité de base (80) pour l'ensemble desdites unités modulaires formant capteurs (10, 20), ces dernières pouvant être ajoutées, retirées et remplacées si nécessaire pour étendre ou réduire la zone d'imagerie dudit système (100) de capteurs et pour en réaliser la maintenance.

7. Système de capteurs selon la revendication 6, caractérisé en ce qu'il comprend un ensemble d'unités modulaires formant capteurs CCD (10) équipé d'un système à fibres optiques (60) connecté à ces unités, et que la surface extérieure des fibres optiques (60) est recouverte par une couche d'un matériau à scintillations (61) apte à convertir l'information d'image convoyée par des rayons X rencontrant le matériau en une lumière dans le domaine visible.

8. Système de capteurs selon la revendication 7, caractérisé en ce que les fibres du système (60) à fibres optiques se rétrécissent avec un faible angle de conicité (a) en direction des éléments détecteurs, ce qui a pour effet qu'une zone d'imagerie continue exempte de limites entre unités peut être obtenue même dans des structures qui ne possèdent pas la zone d'imagerie active des unités formant capteurs (10) s'étendant jusqu'aux bords de ces unités.

9. Système de capteurs selon l'une quelconque des revendications 6 à 8, caractérisé en ce qu'il comprend une unité en forme de cadre pourvue d'une unité de base (80) pour réaliser des connexions mécaniques et électriques permettant la connexion desdites unités électroniques modulaires de commande (20) par l'intermédiaire d'un premier ensemble de connecteurs (65) à ladite unité de base (80) et par l'intermédiaire d'un second ensemble de connecteurs (64) à leurs unités modulaires respectives formant capteurs (10).

10. Système à capteurs selon l'une quelconque des revendications 6 à 9, caractérisé en ce qu'il comprend une unité en forme de cadre (62, 68) incorporant un capot protecteur non transparent (67) transmettant les rayons X équipé desdites unités modulaires formant capteurs (10) disposées selon une disposition bout-à-bout au-dessous du capot, ce qui a pour effet que le côté de ladite unité en forme de cadre (62, 68) situé à l'opposé dudit capot protecteur (67) est pourvu d'ouvertures (63) au moyen desquelles lesdites unités modulaires formant capteurs (10) sont connectées à l'aide desdits connecteurs (64) à leurs

unités électroniques modulaires respectives de commande (20).

11. Système à capteurs selon l'une quelconque des revendications 6 à 10, caractérisé en ce que lesdites unités modulaires formant capteurs (10) sont supportées à la fois longitudinalement et latéralement en position au moyen d'éléments de support (70, 73), au moins certains de ces éléments de support enserrant les côtés opposés de l'ensemble, monté adjacent, d'unités modulaires formant capteurs (10) sont pourvus d'éléments de serrage, très avantageusement d'éléments à ressorts et vis (71, 72, 74 75) convenant pour fixer lesdits ensembles d'unités modulaires formant capteurs (10) auxdites unités en forme de cadres (62) et alignant lesdits ensembles d'unités formant capteurs comme requis.

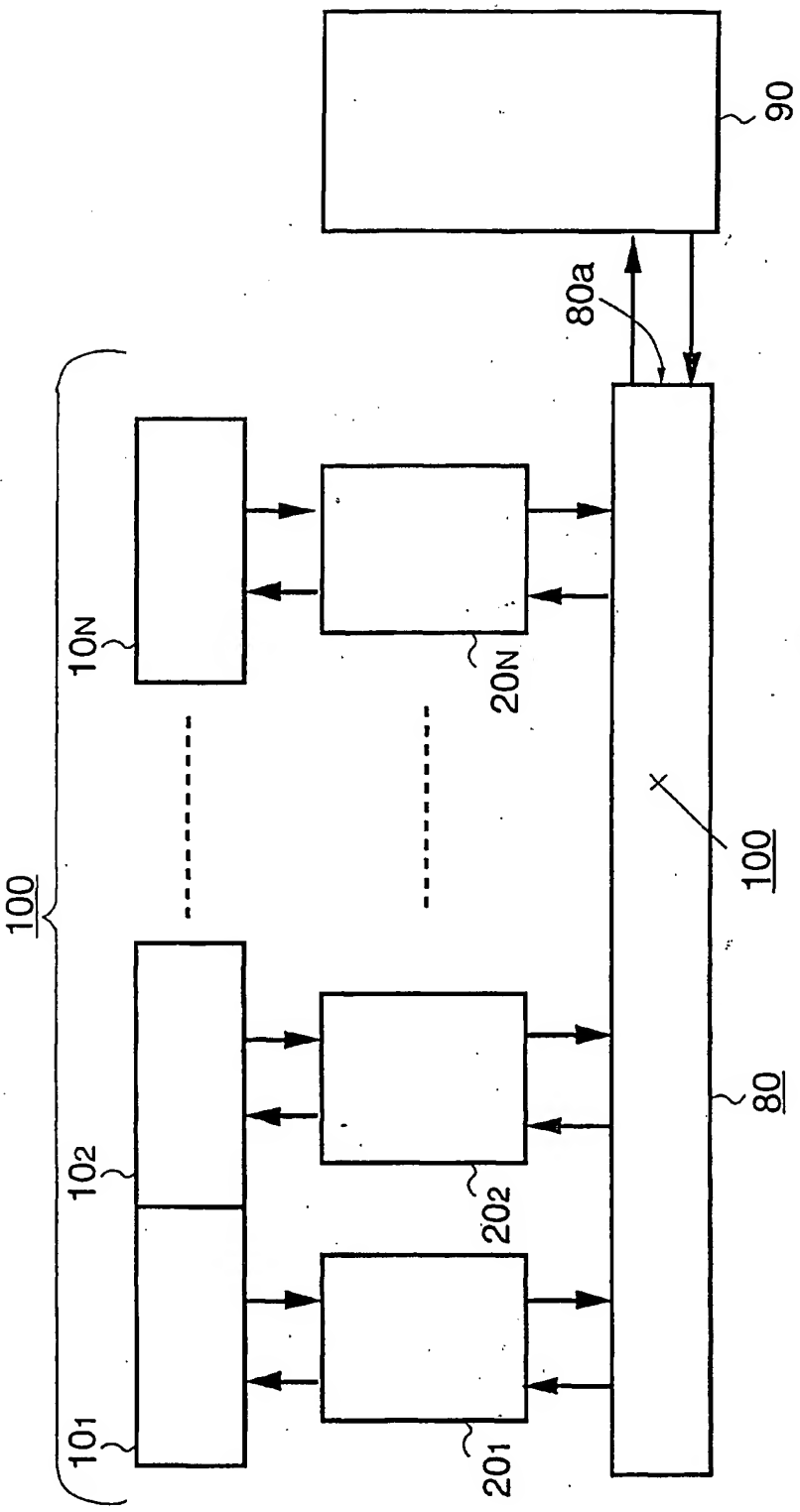


Fig. 1

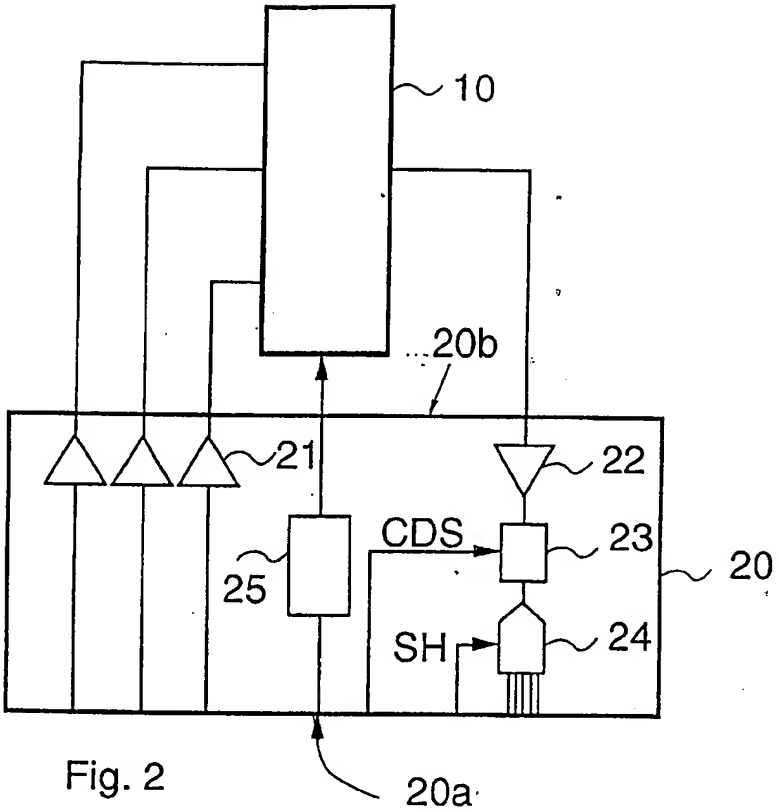

10
20b
21
22
CDS
23
20
25
SH
24
20a

Fig. 2

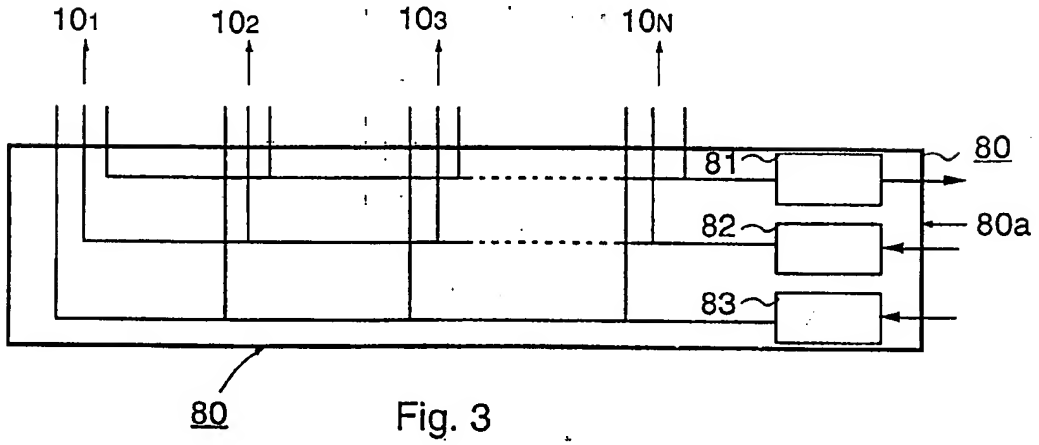

10₁
10₂
10₃
10N
80
81
82
80a
83
80

Fig. 3

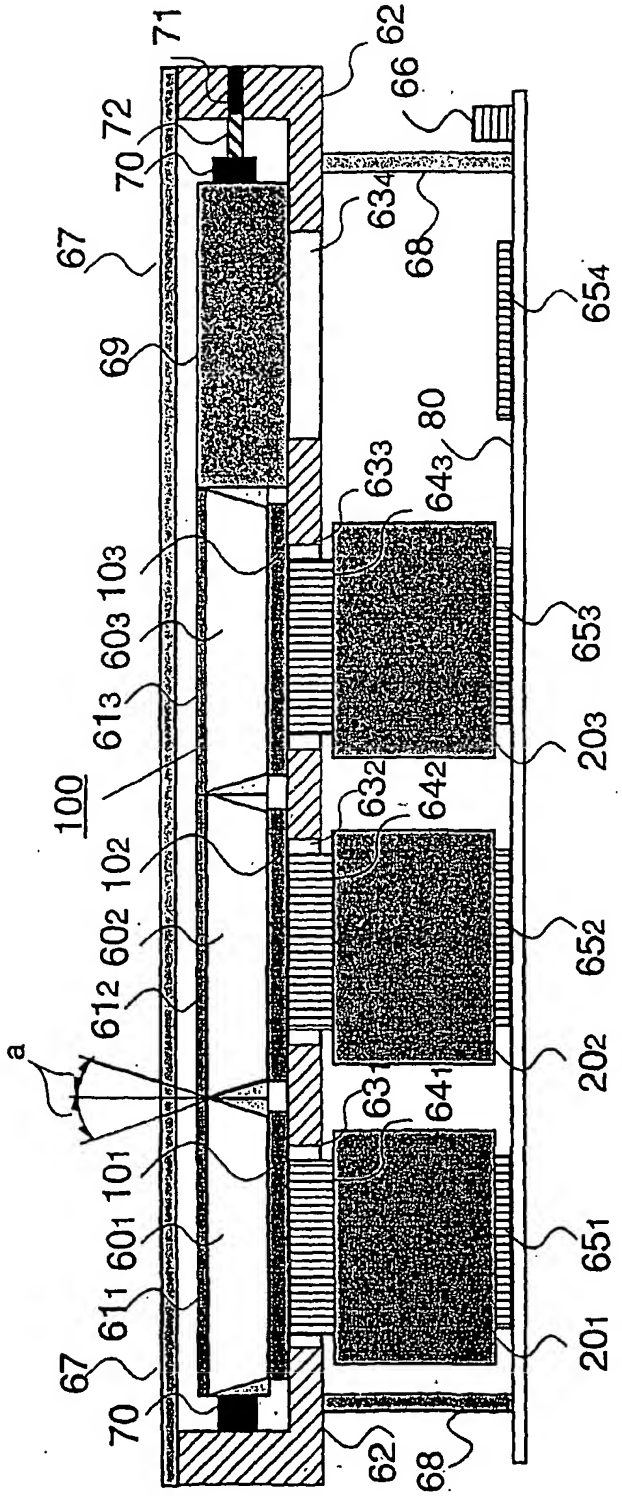

71
62
66
72
70
634
68
67
654
69
80
643
633
653
603
103
613
100
203
642
632
652
602
102
612
a
202
641
631
651
601
101
611
201
67
70
62
68

Fig. 4

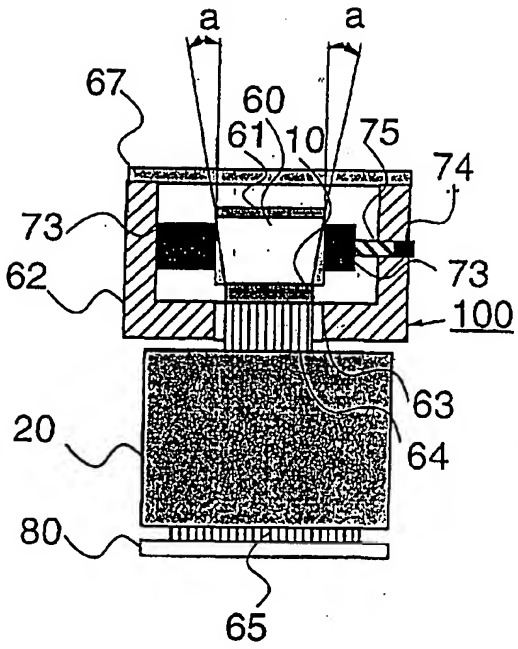
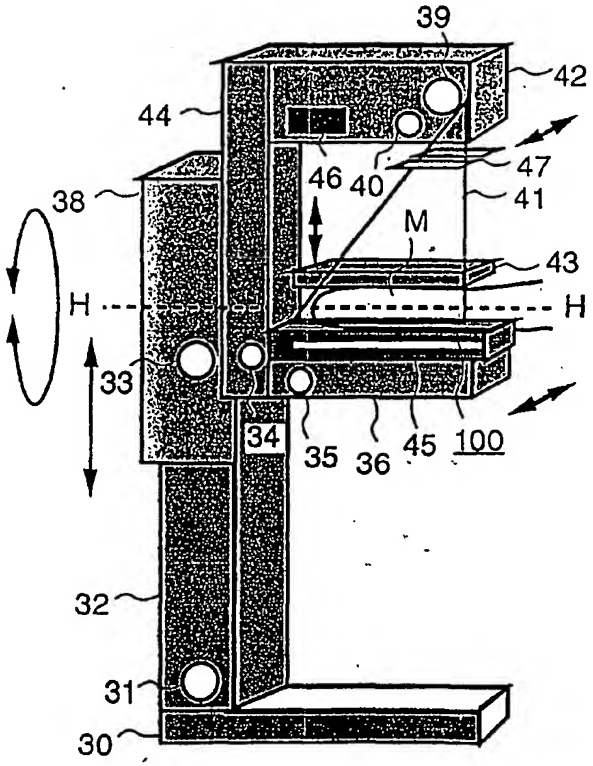

a
a
67
60
61
10
75
74
73
73
62
100
63
20
64
80
65

Fig. 5


39
42
44
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46
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41
38
M
43
H
H
33
34
35
36
45
100
32
31
30

Fig. 6

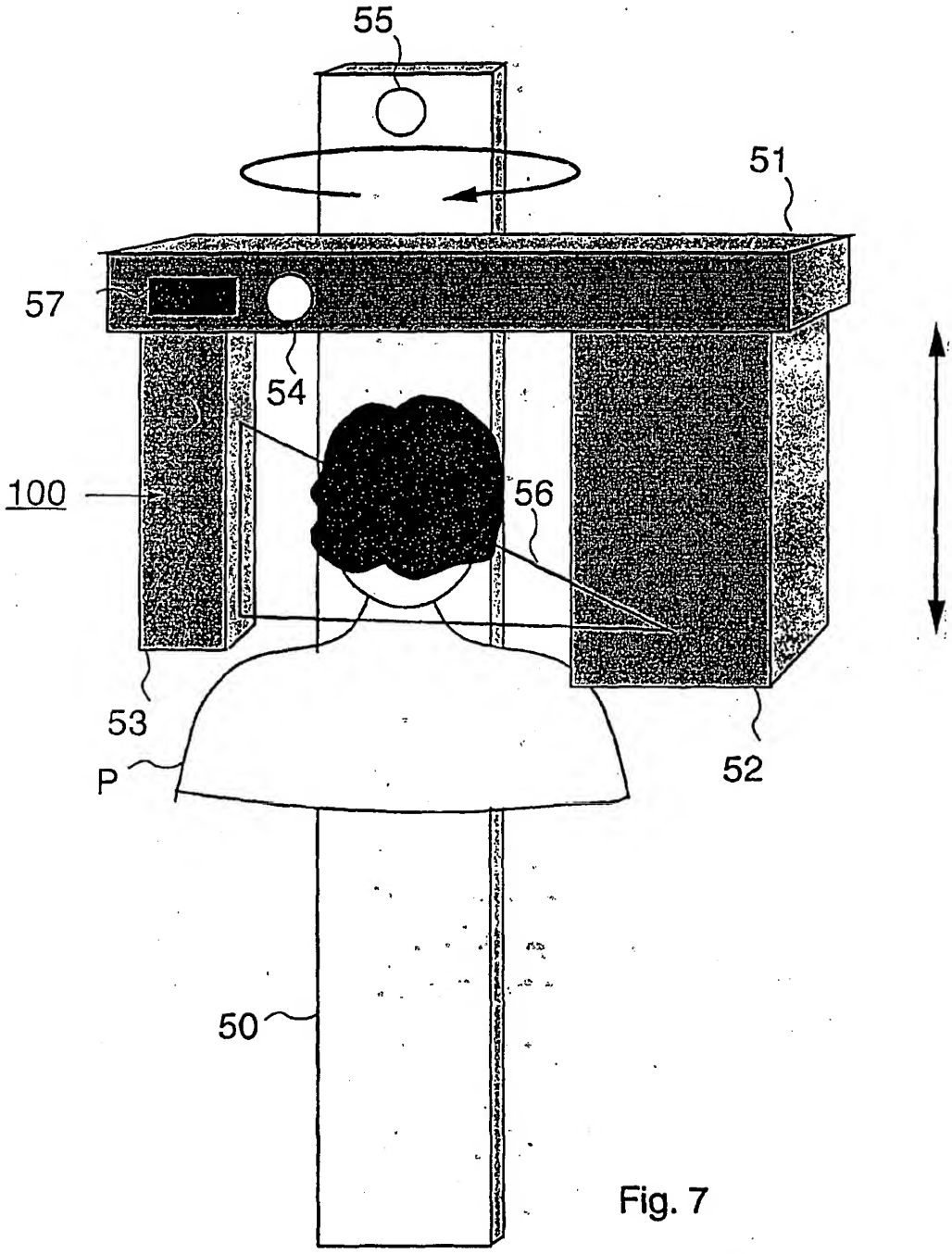

Fig. 7